

TI-83's Awesome Inequalities

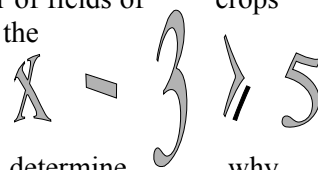
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After receiving a B.S. in Math Education from Miami University, Judy taught junior high math in the Northwest School District. Upon completion of her Master's in Education at Xavier University, she served as a counselor and high school math teacher in the Norwood City Schools. Most recently, she has been at the College of Mount St. Joseph's teaching Mathematics to students seeking a degree in elementary education.

Graphs of linear inequalities can be used to represent real-world problems, such as optimization problems. Once algebra students have become proficient at graphing inequalities on the coordinate plane, they can enjoy using the graphing calculator to investigate various graphing options and immediately compare outcomes. "Students can often come up with strategies and demonstrate expertise in areas where teachers may be deficient" (Armstrong, 1994, p. 17). Using the graphing calculator, such as the TI-83, also allows students who are more logical and sequential in their thinking to use technology to change parameters in such equations and demonstrate what occurs. Students speculate on what will happen when coefficients or constants are changed, and then visualize the results. These situations can later be transferred to real-world problems. Using the graphing calculator allows the student to make changes, and quickly graph the results. The calculator carries out the manipulation of symbolic equations allowing students to easily explore effects of changes in parameters and to better understand linear equations (NCTM, 2000 p. 299). It proves to be a very efficient tool when problems become more difficult and students are not subjected to the drudgery and time constraints of performing such tasks by hand. It is also a beneficial tool to the teacher who can assess, simply by observation, whether students are able to solve the problems presented.

Using manipulatives is helpful in developing mathematical understanding in students (NCTM, 1989). For the visual learner, the graphing calculator is ideal. The *Curriculum and Evaluation Standards for School Mathematics* also lists the four standards, problem solving, communication, reasoning, and connections, as mathematical processes at the core of mathematical understanding for students (NCTM, 1989). By using the graphing calculator, all four of these standards can be integrated into the curriculum.

Take, for example, the following problem. A farmer must have at least five fields of his crops grow in order to provide a return on his investment. Each year approximately three fields are lost due to natural disasters. How many fields must he plant to yield a profit? The problem is neither difficult to solve nor does it produce a very interesting graph, but it is a good a starting point to begin graphing inequalities. The simple inequality represented here is $x - 3 \geq 5$, where x represents the number of fields of crops the farmer plants. Students can visualize that the solution must be greater than the constant value when the inherent equation is solved. The students can draw quick sketches on a sheet of blank paper demonstrating what they think will appear on the calculator screen. This can engage the students and provide a check for understanding. The teacher can model imperfect drawings and have the students determine why the graphs are incorrect. This can be done in groups and presented to the entire class. In this inequality, the graph is directed to the right of 8 and includes 8. If the teacher suggests that the graph be posed to the left, students can argue that 7, 6, 5, etc. are not solutions. In his book on multiple intelligences, Thomas Armstrong suggests using Socratic questioning so that students can share their hypotheses. "The teacher guides the testing of these for clarity, precision, accuracy, logical coherence, or relevance through artful questioning" (Armstrong, 1994, p. 70).



Graphing Inequalities in One Variable

In the first example, $x - 3 \geq 5$, most sketches should be accurate because of previous work done on the coordinate plane. Now, the students are ready to input the necessary information into the graphing calculator.

First, the students must set the viewing WINDOW for the optimum display of the graph by pressing the WINDOW key to display the current values used for the maximum and minimum values of the variable. Below are the standard values, which will give a symmetrical display of all four quadrants on the coordinate graph.

In addition to setting the WINDOW shown here, which are the default values in the graphing mode, it would be a good idea to see that all default values are selected on the 2nd/FORMAT screen. The default values are all those in the left-hand column.

Screen Display
WINDOW FORMAT
Xmin = -10
Xmax = 10
Xscl = 1
Ymin = -10
Ymax = 10
Yscl = 1

This simply means that the viewing domain is $[-10, 10]$ and the viewing range is $[-10, 10]$. The distance between tick marks is one for both the x and y -axis according to the Xscl and Yscl (short for scale). Should any of the parameters be different and need to be changed, simply move the up or down cursor to the variable to be changed. Press CLEAR and then enter a new value. Note that an error message will appear if the Xmin is not less than the Xmax (Texas Instruments, 1996).

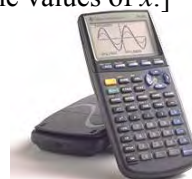
To graph inequalities in one-variable on the TI-83 calculator, use the Y= key to input the inequality. Use the TEST key to retrieve the inequality symbol. Since TEST is above the MATH key, the 2nd key must first be pressed followed by the MATH key to activate this second function. (One key may have many uses.) Once the 4 key is pressed under this mode, the \geq sign will appear on the screen. A more simplified

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explanation is shown below. Words, which are fully capitalized, represent titles of keys. Each keystroke inputs a value or information, which appears on the Home screen. This is the primary screen where values can be entered. For the remainder of this article, brackets are used to indicate when to use the 2nd key to retrieve the word, symbols, or letters above a key [shown in brackets]. The x used is the first of four symbols next to the ALPHA key. When that key is

pressed in this mode, x will appear on the screen.

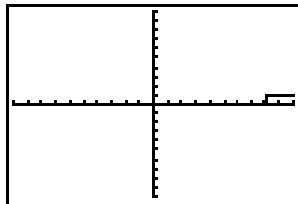
Pressing the GRAPH key after all functions are entered graphs the functions. A graph then appears on the display screen of the coordinate plane of the viewing window - assuming the range values selected are appropriate for the domain values. When entering the inequality below, be sure to choose the correct keys for the minus sign and negative sign. These are two different keys, so if one is substituted for the other, a syntax error will appear instead of a graph. [Editor note: Only functions can be entered in the Y= editor. In the case of $x - 3 \geq 5$, it is a logical function and has a value of 0 or 1 depending on the values of x .]



EXAMPLE 1: $x - 3 \geq 5$

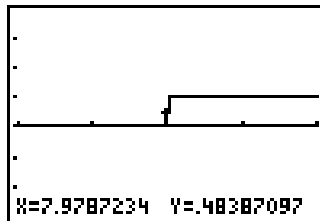
<u>Keystroke</u>	<u>Screen Display</u>
Y ₁ =	Y ₁ =
X - 3 [TEST] 4	Y ₁ = x - 3 ≥
5	Y ₁ = x - 3 ≥ 5

GRAPH



The graph shows $y = 1$ for all x -values for which the inequality is true, and $y = 0$ for all x -values for which the inequality is false. To have a closer view of the solution values, use the ZOOM key. In this mode, select 1: ZBOX to draw a box around the values at the far right side of the screen. When ENTER is pressed, the $X = 0$ and $Y = 0$ are displayed. The zoom cursor will flash at the center of the screen.

Move the cursor to the right until X is near 7 or anywhere desired to define the corner of the box. A small, square dot indicates the box. Move the cursor keys right, left, up, or down to shorten or lengthen the box (Texas Instruments, 1996). Press ENTER again and a larger version of that portion of the graph will appear.



Press the CLEAR button to return to the Home screen before drawing a new graph. It is also necessary to CLEAR the Y= screen before going to the next section to prevent the one-variable graph from showing up on the two-variable graph.

Graphing Inequalities in Two Variables

To graph inequalities in two variables on the TI-83 calculator, use the shade options that are embedded in the Y= menu. Let us return to the farmer for an example of how to use this feature.

The farmer has enough land to plant 12 fields. A field of wheat takes up the space of three fields of corn. Draw a graph to show all the possible combinations of wheat and corn that can be planted in the fields. If x is the number of fields of corn and y is the number of fields of wheat, then $x + 3y \leq 12$ or $y \leq 4 - x \div 3$.

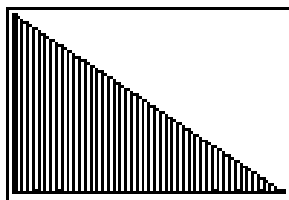
Since we are only concerned with positive values, and the graph crosses the axes at $(0, 4)$ and $(12, 0)$, the WINDOW values can be reset to display only the first quadrant such that $0 \leq x \leq 12$ and $0 \leq y \leq 4$. Let Xscl and Yscl remain one.

EXAMPLE 2: $y \leq 4 - x \div 3$

<u>Keystroke</u>	<u>Screen Display</u>
Y=	Y ₁ =
$4 - x \div 3$	Y ₁ = $4 - x / 3$

To determine whether to shade above or below the graph, use the TRACE key to move along the function. As the cursor moves along the function the corresponding coordinates are displayed on the bottom of the screen (Texas Instruments, 1996). These can be rounded up or down and substituted into the original inequality to find possible solutions.

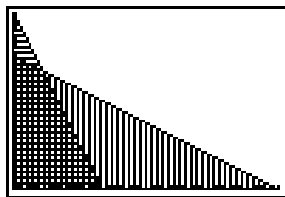
It should be determined that the boundary below the graph must be shaded to represent all possible solutions. This can be done from the $Y =$ menu. Move the cursor to the left of the $Y_1 =$ (to the first column) where there is a diagonal line, and press ENTER to cycle through seven graph styles available. Select or stop at the “below” graph style icon to shade under the region. Press GRAPH.



Graphing Inequalities Simultaneously

Now, for one last example again using the farmer. It takes two hours to pluck a chicken and four hours to butcher a pig. He, his wife, and his son work a total of 120 hours per week plucking chickens and butchering pigs. His daughter works about 40 hours per week, packing the meat. It takes her about two hours to pack one chicken for market and one hour to ready each pig. Given possible constraints, find the feasible region for the number of chickens and pigs ready for the market in one week.

The two inequalities representing this problem are $2x + 4y \leq 120$ and $2x + y \leq 40$ if x = the number of chickens and y = the number of pigs. Again, reset the WINDOW such that $0 \leq x \leq 60$ and $0 \leq y \leq 40$. Let Xscl and Yscl be 10. Simplify the inequalities for the $Y=$ menu to $Y = 30 - 0.5x$ and $Y = 40 - 2x$. Input both equations, and follow instructions on the previous example to shade below the boundary. This can be done before or after inputting the equations. Hit the GRAPH button and the graph will be displayed as follows. Use the TRACE key and cursor keys to move along the graph or move from one slope to the other. Test the values to find the feasible region. The optimal workweek is near the point of intersection.



Conclusion

Bernice McCarthy in *The 4Mat System* says, “It is imperative that we incorporate learning preferences that speak to all of our students” (McCarthy, 1987, p. 40). The graphing calculator integrates teaching with technology, and awakens dormant learning styles. Using this visual aid stimulates students who are logical and sequential in their thinking. Using it is also gratifying for the educator in that students who show little interest in graphing topics can be engaged in this type of problem solving. Use of the calculator also allows the students to experience success when paper and pencil errors become a frustration. Some students seem to be naturally at ease with this instrument, and generally in awe of the results that they can direct the calculator to produce.

References

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